How long does it take? Reliable personality assessment based on common behaviour in cotton-top tamarins (Saguinus oedipus)

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Title: How long does it take? Reliable personality assessment based on common behaviour in cotton-top tamarins (*Saguinus oedipus*).

Running head: Personality assessment method

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Highlights

- Coding of common behaviours represents reliable method of personality assessment.
- Behaviour coding is not necessarily time-consuming personality assessment method.
- Five observational hours per individual were sufficient for personality evaluation.
- Two personality components were described for cotton-top tamarins.

Abstract

Individual variation in behaviour has been shown to have important ecological and evolutionary consequences. Research on animal personality has therefore received considerable attention, yet some methodological issues remain unresolved. We tested whether assessing personality by coding common behaviours is as time-consuming method as some researchers believe it to be. Altogether, 300 hours of observation were collected on 20 captive cotton-top tamarins (*Saguinus oedipus*). We first examined the repeatability of behavioural indices that represented the behavioural repertoire of cotton-top tamarins. We then compared the personality structures, based on different lengths of observation time, of these behavioural indices. The minimum observational time necessary to obtain a stable personality structure was 5 to 7 hours per individual. This stable structure included two components: Extraversion and Confidence, which were similar to those described in great apes, Old World monkeys, and other New World monkeys. Our findings suggest that, at least in the case of cotton-top tamarins, behavioural coding over relatively short periods of time can be used to assess personality and that longer observation periods may yield diminishing returns.

Keywords: animal personality; behavioural observation; Callitrichidae; consistency; continuous focal recording

1. Introduction

Personality traits have been described in species throughout the animal kingdom (reviewed in Bell et al., 2009; Freeman and Gosling, 2010; Gosling, 2001) and have far-reaching ecological and evolutionary consequences (reviewed in Réale et al., 2007). However, methodological issues relating to personality assessment remain unresolved (e.g. Carter et al., 2013).

Despite personality in animals having been studied since the 1970s (e.g. Chamove et al., 1972; Huntingford, 1976; Stevenson-Hinde et al., 1978) and earlier (reviewed in Whitham and Washburn, 2017), currently animal personality research is pursued predominantly by behavioural ecologists and comparative psychologists. Although there is overlap between these disciplines, they differ in how they conceptualise animal personality, which species they study, and which methods they use (Carter et al., 2013; Koski, 2011a; Weiss and Adams, 2013). To summarise, behavioural ecologists typically measure individual variation in a single trait and so assess narrow aspects of personality; their study subjects are usually small mammals (Kanda et al., 2012), birds (Carere and van Oers, 2004), fish (Wilson et al., 2010), or invertebrates (Stanley et al., 2017), all of which are easily subjected to experimental tests of personality, such as the open field test (Perals et al., 2017). The personality traits that behavioural ecologists study most often include activity, aggressiveness, boldness, exploration and sociability (Réale et al., 2007; Sih et al., 2004). Comparative psychologists, on the other hand (like human personality psychologists) tend to examine multiple, structured traits (e.g. Garai et al., 2016). The resulting models, derived from data reduction techniques, such as factor analysis (FA) or principal components analysis (PCA), reflect latent constructs that describe patterns of covariation among these traits (Digman, 1990). The human Five-Factor Model or “Big Five”, consisting of personality dimensions labelled Agreeableness, Conscientiousness, Extraversion, Neuroticism, and Openness (Digman, 1990), has been a useful framework for comparing species (Gosling and John, 1999; Weiss, 2017), especially when applied to nonhuman primates, to humans and one another (e.g. Weiss et al., 2011).

There are several methods of personality assessment (see Freeman et al., 2011 and Vazire et al., 2007 for reviews). One method is to gather ratings of traits by knowledgeable informants. Another method is to conduct behavioural tests and to record (or code) the behaviours performed by the animals in the experiments (hereafter "experimental coding"). A third method is to record naturally occurring everyday behaviours (hereafter "common behaviour coding"). These three methods overlap to a certain degree and have been used to validate one another as in, for example, a study of hanuman langurs (Konečná et al., 2008). These methods also can complement one another as in a study of common marmosets (*Callithrix jacchus*) where behavioural coding revealed a "Neuroticism" that did not emerge from trait-ratings in the same sample (Iwanicki and Lehmann, 2015).

Common behaviour coding is based on methods used in classical ethology. It therefore involves recording frequencies and durations of behaviours that are predefined in ethograms by means of different methods of observation, such as continuous focal recording, instantaneous sampling, or scan sampling (Martin and Bateson, 2007). By recording a broad range of everyday, naturally occurring, behaviours and subjecting them to data reduction analyses one can identify how behavioural traits within a species are organised by seeing how they "cluster" in the same components or factors (Itoh, 2002; Koski, 2014). Therefore, this method is potentially useful for studying personality structure and conducting cross-species comparisons. Moreover, common behaviour coding is an ecologically relevant method as the behaviour of an individual is measured in its natural environment and in natural social settings (Koski, 2011a). Yet, so far, not many animal personality studies have involved common behaviour coding in personality model assessment (some exceptions include Anestis, 2005; Freeman et al., 2013;

Garai et al., 2016; Iwanicki and Lehmann, 2015; Konečná et al., 2008; Neumann et al., 2013; Pederson et al., 2005; Robinson et al., 2018; Sussman et al., 2014, 2013).

Assessing personality variation via observations of behaviours can benefit both behavioural ecology and comparative psychology. For example, behavioural observations can be used to validate other measures such as personality questionnaires (Konečná et al., 2008) or experiments (Neumann et al., 2013). Behavioural observations can also be used to measure personality in species that are difficult to study in laboratory settings (e.g. large or endangered species), species that are not found in sufficient numbers in the field (e.g. solitary species), or species that are prone to stress when separated from conspecifics for the purpose of individual testing (e.g. group-housed laboratory animals). Common behaviour coding can also be used to study personality in captive or wild individuals when there are no potential raters available.

Although it has been shown that common behaviour coding can contribute to animal personality research, the perception that long periods of time need to be devoted to gathering these observations (Freeman et al., 2011; Itoh, 2002) may have led some researchers to prefer trait rating or behavioural experiments. However, it is not clear how much time needs to be devoted to behavioural observations if one is to obtain representative data for constructing stable personality models. Indeed, the length of behavioural observations reported for personality studies varies substantially from 2 (Vazire et al., 2007) to 66 hours (Neumann et al., 2013) of mean observation per individual. In some studies, the observation time can be highly variable as it depends on the visibility of focal individuals. For example, Neumann et al. (2013) reported between 0.6 and 130 hours of observation time per individual. Observation time that is too short might miss meaningful but rare behaviours and may be susceptible to bias arising from temporal fluctuations in an animal's state, its environment, or in the situations in which it finds itself (Freeman et al., 2011; Vazire et al., 2007). Extensive observational hours, on the other hand, might be an unnecessary investment of scientific resources. Ideally, then, researchers need to spend enough time to obtain an adequate sample of behavioural data but not spend time or scientific resources that could be invested elsewhere.

The present study sought to determine how much sampling effort was needed to derive stable personality traits and individual variation in each trait from common behaviours in captive cotton-top tamarins, a cooperatively breeding primate species from the family Callitrichidae. Although evidence for the existence of consistent personality traits has been already demonstrated within this clade (Addessi et al., 2007; Day et al., 2003; Franks et al., 2013; Koski and Burkart, 2015; Šlipogor et al., 2016), personality structure based on common behaviour coding has so far only been examined in common marmosets (Iwanicki and Lehmann, 2015). In our study, we tested the repeatability of each behaviour within our dataset and then proceeded subject reliable behaviours to data reduction analyses (PCA and REFA) to derive a personality structure for our subjects. We then compared how this personality structure, i.e., the number and characteristics of the components or factors, differed as a function of varying levels of observation length.

2. Methods

2.1. Subjects

Subjects were 20 captive-born cotton-top tamarins that lived in five zoos located in the Czech Republic and Slovakia: Zoo Bojnice, Zoo Bratislava, Zoo Jihlava, Zoo Ostrava, Zoo Ústí nad Labem. The subjects included eight females (mean age in months ± *SD* = 75.7 ± 46) and 12 males (mean age in months ± *SD* = 59.4 ± 54.5). With the exception of the tamarins in Ostrava, each group consisted of a breeding pair and their offspring (see Table 1 for group composition and demographic data). Only adults and subadults were observed as focal individuals.

All facilities are members of the European Association of Zoos and Aquaria and meet the conditions of animal welfare (Bairrão Ruivo and Stevenson, 2017). Tamarins were housed in indoor enclosures equipped with branches, ropes, shelves, sleeping boxes and other sources of enrichment. One group (Zoo Ostrava) also had access to an outdoor enclosure at the time of data collection. Tamarins were fed a mixture of commercial prepared food and fresh food two to four times each day. Water was always available.

Table 1

Composition and demography of observed groups.

Zoo	Adult	Subadult	Juvenile	Infant
Bojnice	**1F, 1M**	2M	2F	2F
Bratislava	**1F, 1M,** 1M			1F
Jihlava	**1F, 1M**	1F, 1M	1M	1F,1M
Ostrava	**1F,** 1F, 2M			
Ústí nad Labem	**1F, 1M,** 2M	1F		1M

Note. Breeding individuals are shown in bold. F = female, M = male. Adults > 21 mo, subadults 14–21 mo, juveniles 7–14 mo, infants < 7 mo (Cleveland and Snowdon, 1984).

2.2. Behavioural data collection

For the common behaviour coding, we created an ethogram consisting of a broad range of behaviours previously described in tamarins (Coates and Poole, 1983; Edwards et al., 2010; Knox and Sade, 1991; Peñate et al., 2009; Price, 1991; Vogt, 1978). The complete ethogram of 122 items with the 47 behaviours selected for the analyses in bold is presented in Supplementary materials (Table S1).

A combination of focal continuous recording with 30-minute periods and focal instantaneous sampling with 2-minute intervals was used to collect behavioural data (Martin and Bateson, 2007). This enabled us to obtain frequencies from continuous recording and proportions from instantaneous scans. During focal observations, all behaviours of the focal individual were recorded, including the identity of social partners, which included infants, and the direction of social interactions. In instantaneous samples, the location (type of substrate) was also recorded. Not all of the study groups included infants, and as such any interactions with infants were omitted from the analyses. The order of focal individuals was counterbalanced so that focal periods for individuals were distributed evenly throughout the day and the study period. There were 12 focal sessions per day with each focal animal being observed from 2 to 4 times depending on the group size. Each individual was observed for 15 hours in total within 8 to 13 days.

Altogether, 300 hours of observation were collected from July 2011 to February 2012 by MM using a voice recorder (Olympus VN-8700PC Digital Voice Recorder). The observations were conducted from an area for visitors. Each group was given 2 days to acclimatise to the presence of the observer. MM identified individual tamarins using distinct facial or body features, such as body size, face shape, the presence of scars or warts, the size and shape of white head tufts and the shape of the tail.

2.3. Behavioural indices

Twenty-three behavioural indices (see Table 2) representing behaviours ranging from activity to social interactions were created from recorded behaviours. Using behavioural indices to assess personality provides a more detailed account of behaviour than simple behaviours as they take relations between different behaviours into account and correspond more to the use of questionnaire items (Konečná et al., 2008) (for examples, see Tables S19–S20). Indices based of frequency, proportions and diversity indices (Shannon and Weaver, 1963) were computed. The selection of indices was based on previous studies (Anestis, 2005; Garai et al., 2016; Iwanicki and Lehmann, 2015; Konečná et al., 2008) and on the frequency of the observed behaviours. The latter was important to demonstrate interindividual variation, especially when dividing the observation times into relatively short periods (see section *2.6. Time-constrained models*). The indices were transformed into *z*-scores for all analyses.

Table 2

List of behavioural indices and their definitions used in principal components analysis.

Behavioural category	Index	Type of observation	Calculation
activity	*Resting*^{P}	I	(rest + look + watch + sit + lie) / (move + jump + cling + hang)
	Activity diversity^S	I	Shannon diversity index of activity types
	Substrate diversity^S	I	Shannon diversity index of substrate types
self-directed	*Self-grooming*^{F}	C	self-groom/hour
	Scratching^F	C	scratch/hour
surroundings dirrected	*Object sniffing*^{F}	C	object sniffing/hour
	Exploration^F	C	(exploration + object manipulation + search)/hour
	Vigilance^F	C	alert/hour
	Monitoring^P	I	watch/sample
socio-positive	*Affiliation*^{P}	I	[contact + proximity + social play + groom(in) + groom(rec)]/hour
	Passive affiliation^P	I	(contact + proximity)/[contact + proximity + social play + groom(in) + groom(rec)]
	Grooming(in)^F	C	groom(in)/hour
	Grooming(rec)^F	C	groom(rec)/hour
	Invite grooming(in)^F	C	groom invite(in)/hour
	Invite grooming(rec)^F	C	groom invite(rec)/hour

	Approaches(in)[F]	C	approach(in)/hour
socio-negative	*Contact aggression(in)*[F]	C	(general aggression + bite + beat + grab + grasp + chase + fight + face + push + displace)/hour
	Threats(in)[F]	C	(facial threat + open mouth display + headshake + body display + tongue flick)/hour
dominance	*Scent marking*[F]	C	scent marking/hour
	Carrying food away(in)[F]	C	carry food away(in)/hour
	Terminate grooming[F]	C	terminate grooming(in)/hour
	Grimace[F]	C	grimace/hour
	Departures(in)[F]	C	departure(in)/hour

Note. P = based on proportion of time, S = computed as Shannon diversity index measuring and explaining the variation in diversity of a particular variable with higher values indicating higher variability (Shannon and Weaver, 1963), F = calculated as frequency, (in) = behaviour initiated by focal individual, (rec) = behaviour received from an individual, C = continuous recording, I = instantaneous sampling.

2.4. Repeatability

Consistency of behaviour over time (e.g. whether an individual is consistently more aggressive than others) is a fundamental aspect of animal personality (Gosling, 2001; Réale et al., 2007; Sih et al., 2004). To examine the consistency of behaviour in time, and thus appropriateness of the behaviour for personality analyses, we determined the repeatability of each behavioural index. Repeatability is the proportion of behavioural variation that is due to interindividual differences compared to within individual variation (Bell et al., 2009). High repeatability estimates imply that individuals behave differently from each other and at the same time behave consistently over two or more observation periods (Bell et al., 2009). To do so, we divided the observation into 3 5-hour time blocks and computed the behavioural indices for each time block. The reasoning for dividing observations into 3 time blocks was two-fold. First, we wanted to test the repeatability of behaviours collected over several time periods long enough to enable reasonable data aggregation within each period. Second, the time blocks enabled us to cover several days of observation (3–5 days per block) and so to reduce measurement error (Epstein, 1983). The repeatability was analysed using linear mixed-effects models (Nakagawa and Schielzeth, 2010). The 95% confidence intervals and *p*-values were calculated by means of 1000 bootstrap runs and 1000 permutations, respectively. As recommended by previous studies (Schuster et al., 2017), we interpreted the estimates of repeatability regarding both the confidence interval and *p*-values simultaneously.

2.5. Data reduction

To determine the number of components to retain for personality models, we performed a parallel analysis (Dinno, 2012; Horn, 1965) and examined the scree plot (Cattell, 1966). Parallel analysis compares eigenvalues derived from observed data to eigenvalues of randomly generated matrices with the same numbers of variables and subjects as the observed data. Eigenvalues of data that exceed the 95^{th} percentile of eigenvalues derived from parallel analysis are retained (Zwick and Velicer, 1986).

Given our small sample size, to examine personality structure, we performed a PCA and a regularised exploratory factor analysis (REFA; Jung and Lee, 2011), as recommended for samples below 50. To improve interpretability of the component or factor structure, we applied a promax (oblique) and varimax (orthogonal) rotation. The oblique rotation produces components that are correlated with one another, whereas the orthogonal rotation provides components that are independent. To interpret the structure, we defined absolute loadings of indices $\geq |0.4|$ as salient. In the case of cross-loadings, indices were assigned to the component or factor with the highest absolute loading.

2.6. Time-constrained models

To estimate the minimum number of observational hours needed to obtain a stable personality structure, we split our data, which was based on 15 hours of observation, into 14 subsets based on various amounts of observation time. Each subset contained one hour of observation per individual less than the previous subset, therefore observation times for subsets ranged from 14 hours to 1 hour per individual. For each subset, we used the data reduction methods described above. This resulted in generating 14 time-constrained personality models.

2.7. Comparison of models

We first compared the personality structure of the full 15-hour model based on PCA and REFA to assess whether our sample size was satisfactory to obtain a stable structure (Jung and Lee, 2011). Second, we compared the promax and varimax solutions of the full model to determine whether we should interpret the correlated or independent dimensions. Third, we compared all 14 time-constrained models to full model based on 15 hours of observation to determine the minimal length of observation needed to get a stable personality structure. We then interpreted the personality structure identified in the full model.

To compare the models' loadings and structure we used targeted orthogonal Procrustes rotations (McCrae et al., 1996), which yield Tucker's congruence coefficients for each factor and for the entire loading pattern (Lorenzo-Seva and ten Berge, 2006).

2.8. Individual variation assessment

To evaluate how well the individual personality scores on each component based on time-restricted models describe the behavioural variation in comparison to full model, we computed three sets of unit-weighted scores for each individual. These scores were computed using time-restricted personality models based on 5, 10, and 15 hours of observation. We then used Pearson's correlation coefficients for those scores to compare whether the rank orders of scores were consistent, making sure to adjust *p*-values for multiple tests using a procedure described by Holm (1979).

All statistical analyses were performed in R (version 3.3.3, 2017) using the psych (Revelle, 2017), paran (Dinno, 2012), and rptR (Stoffel et al., 2017) packages. REFA was computed using MATLAB (version 9.4., 2018).

3. Results

3.1. Repeatability of behavioural indices

The repeatability of the behavioural indices ranged from 0.25 for *Invite grooming(rec)*^{F} to 0.93 *Approaches(in)*^{F} and *Departures(in)*^{F} with a mean repeatability of 0.62 (SD = 0.23) (Table S2). These values were in the range of repeatability reported for other species (Bell et al., 2009). Five indices, however, had lower repeatability, and although the *p*-value indicated significance, the confidence interval included zero. We conducted the same analyses without these indices and the results (personality models, the recommended length of observation) did not change considerably (data not shown). Therefore, we decided to consider all indices as acceptable for further data reduction analyses (Freeman et al., 2013).

3.2. Model comparison

Parallel analysis and the scree plot indicated that there were 2 components in the full data set. The component solution derived from PCA was equal (congruence coefficients 1.00 for both components) to the REFA solution (see Table S3). Therefore, we decided to interpret the PCA structure as it is reported more frequently in the literature (Konečná et al., 2012). Since the correlations between components were negligible, and the structure of components from both solutions were nearly identical, we retained component solution from varimax rotation. For the promax-rotated solution see Table S4.

In subsets based on 2 to 14 hours of observation, parallel analyses and scree plots suggested retaining 2 components. In the subset based on 1 hour of observation per animal, the parallel analysis and scree plot indicated that there was 1 component. Given this result, we considered 1 hour of observation as insufficient and did not examine it further. Time-constrained personality models are provided in Tables S5–S18.

Congruence coefficients comparing the loadings of 14 time-constrained models to loadings from the model derived from 15 hours of observation are presented in Table 3. The structure of time-constrained models based on 2 to 3 hours of observation did not replicate the structure of the full model. At 4 hours of observation, only 1 of the components replicated. The components derived from data based on 5 or 6 hours of observation time, however, replicated those derived from the full data set (all congruence coefficients > 0.89). From 7 hours onward, both components and the structure can be considered equal to full model (congruence coefficients > 0.97). It took less observation time to replicate the second component, which we labelled Confidence, than it took to replicate the first component, which we labelled Extraversion. Specifically, a stable Confidence dimension was obtained after 4 hours and was replicable at 6 hours; to derive a stable and replicable Extraversion dimension required 1 additional hour (Fig. 1).

Although the overall model structure of datasets based on shorter observation periods was replicable, there were minor inconsistencies with respect to assignment of certain indices to dimensions. *Monitoring*^{P} for example, only had a salient loading in models based on ≥ 10 hours. For *Vigilance*^{F} this was true only with ≥ 6 hours of observation time. Only three indices were assigned to different components (*Grooming(rec)*^{F}, *Invite grooming(in)*^{F}, *Resting*^{P}) in the models based on 6 and 5 hours in comparison to the full model.

Table 3

Congruence between models based on different length of observation and full model based on 15 hours of observation.

	Congruence coefficient		
Observation length (h)	Extraversion	Confidence	Model total
1	0.86	0.61	0.74
2	0.72	0.86	0.79
3	0.75	0.81	0.78
4	0.82	0.89	0.85
5	0.89	0.93	0.91
6	0.94	0.97	0.96
7	0.97	0.98	0.98
8	0.98	0.99	0.98
9	0.99	0.99	0.99
10	1.00	0.99	0.99
11	1.00	1.00	1.00
12	1.00	1.00	1.00
13	1.00	1.00	1.00
14	1.00	1.00	1.00

Note. >0.95 models are equal, 0.85 – 0.94 models display fair similarity, <0.85 no similarity (Lorenzo-Seva and ten Berge, 2006).

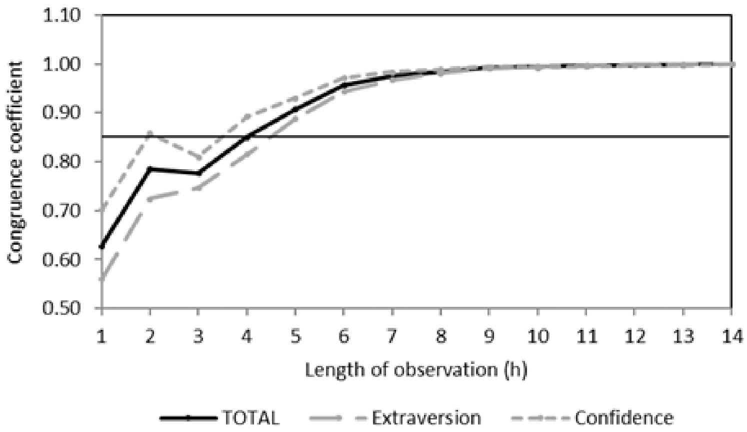

Fig. 1. The relationship between congruence coefficients and the length of observation (hours). Reference line refers to threshold of fair similarity.

3.3. Individual variation

Table 4 shows the correlations of unit-weighted scores for each component of three time-restricted models. Correlations between scores based on 5 and 10 hours and between 5 and 15 hours are slightly lower but still reasonably high and significant ($p < 0.01$). Thus, 5 hours of observation is sufficient for description of individual variation on personality components (Fig. 2).

Table 4

Pearson's correlations of individual personality scores for each component of three time-restricted models.

Observation length (h)	Extraversion (95% CI)	Confidence (95% CI)
15 vs 10	0.98 (0.95, 0.99)	0.99 (0.98, 1.00)
15 vs 5	0.87 (0.70, 0.95)	0.93 (0.82, 0.97)
10 vs 5	0.87 (0.70, 0.95)	0.92 (0.81, 0.97)

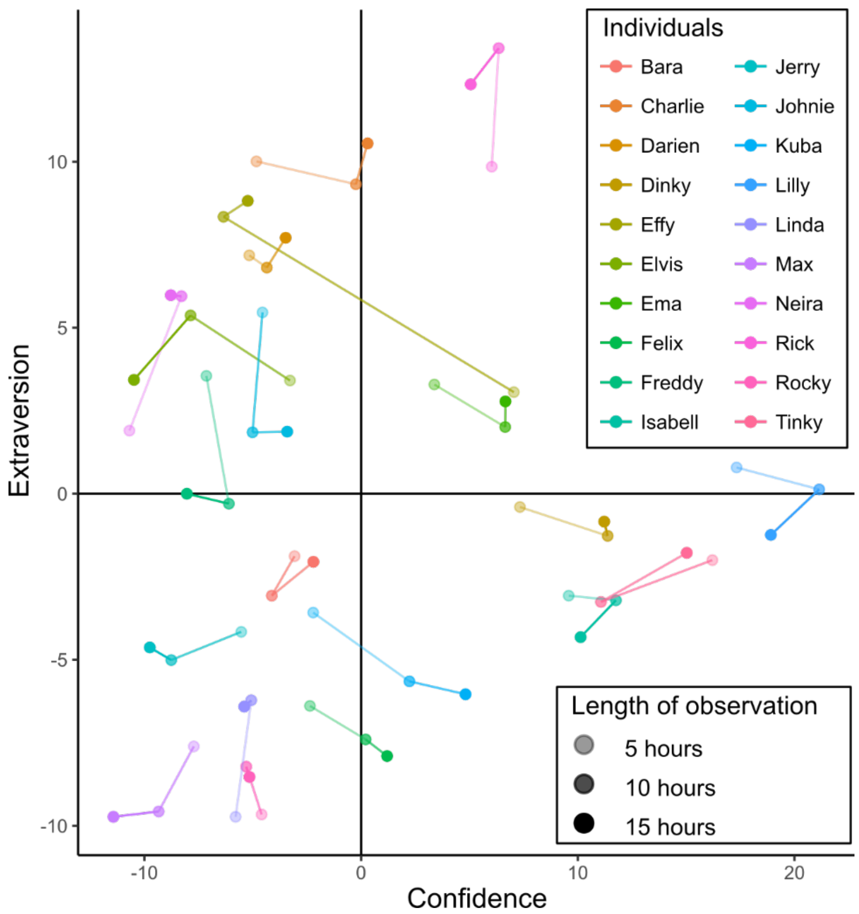

Fig. 2. Individual PCA scores based on the components Extraversion and Confidence for 5, 10 and 15 hours of observation. Scores of each individual are represented by 3 dots connected with a line. Shading indicates the length of observation. See online version for the figure in colour.

3.4. Full personality model

The full personality model with the two components is presented in Table 5. The components explained 54% of the variance. Only one index (*Scent marking*^{F}) did not load on any component. The indices *Vigilance*^{F}, *Terminate grooming*^{F}, and *Resting*^{P} loaded on both components. The first component loaded on indices related to physical and social activity. Individuals who scored high on this component performed a wide range of behaviours (*Activity diversity*^{S}) and preferred active affiliation, such as grooming and social play, to sitting in contact or proximity with conspecifics (*Grooming(in)*^{F}, negative *Passive affiliation*^{P}). This component consisted also of indices related to exploration and active interest in surroundings (*Exploration*^{F}*).* Therefore, we labelled this component “Extraversion”.

The second component was characterized by dominance-related behaviours. Individuals scoring high on this component were confident in their interactions with others (*Approaches (in)*^{F}, *Contact aggression(in)*^{F}) and could acquire resources (*Carrying food away(in)*^{F}, *Grooming(rec)*^{F}). Furthermore, *Scratching*^{F}, which is often identified as an indicator of anxiety and stress in callitrichids (Caperos et al., 2011), loaded negatively on this component. Given these features, we labelled this component “Confidence”.

Table 5

Personality model of cotton-top tamarins. Varimax rotated solution of principal components analysis.

	Component		
Behavioural index	Extraversion	Confidence	Communalities
Activity diversity^S	**0.89**	0.29	0.87
Passive affiliation^P	**-0.88**	0.09	0.79
Exploration^F	**0.88**	0.00	0.77
Threats(in)^F	**0.88**	-0.06	0.77
Vigilance^F	**0.72**	**-0.42**	0.69
Grooming(in)^F	**0.71**	0.35	0.62
Invite grooming(rec)^F	**0.68**	0.04	0.46
Terminate grooming^F	**0.64**	**0.41**	0.58
Resting^P	**-0.63**	**-0.44**	0.59
Grimace^F	**0.59**	-0.12	0.36

Object sniffing[F]	**0.49**	-0.34	0.36
Monitoring[P]	**0.43**	-0.09	0.19
Self-grooming[F]	**0.40**	-0.22	0.21
Departures(in)[F]	-0.17	**0.92**	0.88
Approaches(in)[F]	-0.07	**0.85**	0.72
Scratching[F]	-0.12	**-0.84**	0.72
Affiliation[P]	-0.25	**0.80**	0.70
Contact aggression(in)[F]	-0.05	**0.76**	0.58
Carrying food away(in)[F]	-0.17	**0.65**	0.45
Grooming(rec)[F]	0.05	**0.62**	0.38
Substrate diversity[S]	0.30	**0.58**	0.42
Invite grooming(in)[F]	0.21	**0.45**	0.25
Scent marking[F]	0.34	0.10	0.12
Explained variability	29%	25%	

Note. N = 20. Salient loadings are in boldface. P = index based on proportion of time, S = index computed as Shannon diversity index, F = index calculated as frequency, (in) = behaviour initiated by focal individual, (rec) = behaviour received by focal individual.

4. Discussion

A PCA of commonly observed behaviours that had moderate to high repeatability unveiled two personality components, Extraversion and Confidence, in cotton-top tamarins. Comparisons of the personality structures based on different lengths of observation indicated that 5 hours of observation time per individual were sufficient to obtain a replicable personality structure and a stable description of individual variation.

4.1. Common behaviour coding method

Behavioural coding has often been considered time-consuming and thus has not been used as often as other methods of collecting personality data (Freeman et al., 2011; Itoh, 2002). Our results, however, indicate that long observations might not be necessary for assessing personality. In cotton-top tamarins, stable personality structure was revealed after 5 hours of observation per individual. After 7 hours of observation time, both components and the overall structure were nearly identical to the full model.

The minimum length necessary to obtain stable personality assessment might differ across personality dimensions. Our results indicate that Confidence takes less time to assess than Extraversion. Similarly, research on humans reported that some traits are more “visible” and thus easier to judge than others (Funder, 2012). Behaviours related to Confidence could have been easier to observe due to their higher frequency, as these behaviours are important in social animals that have to cope with complex individualised social relationships on a daily basis. Confidence-related behaviours also play a crucial part in callitrichid social groups, where reproductive suppression can impose intense competition (Digby et al., 2006).

For this study, we analysed behaviours that occurred more frequently which could have also contributed to significant reduction of the overall sampling effort. Recording rare but species relevant behaviours, such as food sharing in tamarins, would probably extend the length of observation. Age-sex classes should also be considered as certain behaviours might be more prevalent in males or females or in different age categories. For example, severe aggression is more common among male cotton-top tamarins (Snowdon and Pickhard, 1999). Similarly, individuals in larger groups might have more opportunities to express social behaviours than individuals in smaller groups or pairs of individuals, thus the behaviour is more rapidly accumulated. The effect of those variables on data accumulation in the context of animal personality, however, remains to be tested.

The overall sampling effort in terms of observation length can also be influenced by the selection of the sampling method and the design of observation. In our study, we used a combination of continuous and instantaneous focal sampling methods, which together enabled us to record different types of information and thus collect the data more efficiently. Scan sampling of the group could further reduce the workload of observers as it allows one to measure behaviours in several animals within one period (Martin and Bateson, 2007). Furthermore, the length of the focal observational period or scan interval can influence how fast the data accumulate, with shorter periods and intervals possibly accumulating data faster (Edwards et al., 2010; Kawanaka, 1996). Scheduling the focal periods across several days (in our study the minimum of 5 hours was accomplished within 3 to 5 days) eliminates the influence of unexpected situations (such as severe fights or management intervention in captivity) that may affect the behaviour of an animal on a particular day. The effects of the distribution of focal periods over time, the length of focal period, and the sampling method on personality assessment remain to be tested as well.

It is important to emphasize, however, that the minimum length of observation might be specific to nonhuman primates, New World monkeys, callitrichids, cotton-top tamarins or even just captive populations of cotton-top tamarins. A study on wild chimpanzees, for example, reported 25 hours of observation as the critical length of observation needed for reliable scoring of behaviours and social relationships (Kawanaka, 1996). On the other hand, results from a study on rhesus macaques in captivity suggested that 6 hours of data collection per group were sufficient to provide a reliable group time budget (Nyström et al., 2001). Given that callitrichids are small bodied, active, and have a relatively high metabolism rate, behaviours in this species might accumulate more quickly compared with larger, less active species that have a relatively slow metabolism (Careau and Garland, 2012). Furthermore, the type and quality of a species' diet as well as feeding habits can be directly connected to activity patterns (Baldwin and

Baldwin, 1978; Masi et al., 2009), and thus affect the accumulation of different behaviours. For instance, "energy minimising" folivores, such as howler monkeys (*Alouatta* sp.), spend up to 80% of their daily activities resting (Estrada et al., 1999), compared with the frugivorous-insectivorous black-handed tamarins, which spend only 10% of the day resting (da Silva and Ferrari, 2007). However, more data is needed from a wider variety of species in order to determine whether body size or feeding ecology, indeed influence the rate of accumulating behaviours related to personality.

Finally, depending on group size, 5 hours of observation per individual can be considered time-consuming and requiring more effort compared to other methods. However, preparation of experiments, from designing an apparatus, habituating animals, conducting the experiments to necessary pauses between tests, can also take up a considerable amount of time, in particular when researchers seek to evaluate several personality dimensions. Using questionnaires for trait rating might seem to be the quickest method, however, it is only shorter if well-acquainted raters are available. In other cases (e.g. Konečná et al., 2008), raters must spend several months observing individuals before they can even begin rating. Moreover, long forms (e.g. HPQ with 54 adjectives; Weiss et al., 2009) can take considerable time to complete. Interestingly, the time demands of different personality assessment methods have only been discussed but not empirically examined (Freeman et al., 2011; Vazire et al., 2007).

4.2. Repeatability of behaviours

The majority of behavioural indices used in the current study were either highly or moderately reliable across three observation periods, representing a short time span. Still, there was some variation. Indices with lower repeatability included those related to grooming interactions, namely *Grooming(rec)*^{F}, *Invite grooming(rec)*^{F}, *Grooming(in)*^{F}, *Terminate grooming*^{F}, and self-grooming (*Self-grooming*^{F}). One possible explanation of lower stability estimates is that social grooming indices are, by definition, a function of the social environment.

Therefore, the lower stability of social indices might be attributable to the fact that their occurrence is dependent on the behaviour of the focal individual and its social partners at the same time. Some studies have found that grooming-related indices were repeatable (Blaszczyk, 2018; Koski, 2011b; Neumann et al., 2013), although the indices based on received social interactions were less repeatable than the indices based on initiated social interactions (Blaszczyk, 2018; Koski, 2011b). Alternatively, grooming behaviours might be context specific and therefore represent several different traits (Carter et al., 2013; Gosling, 2001). Grooming is most often thought of as an affiliative action but in cooperative breeders it can also be used to induce helpers to stay in the group (pay-for-help strategy) (Ginther and Snowdon, 2009) or to reduce the tension of these helpers (Caperos et al., 2011).

Other indices that could have been influenced by context are *Scent marking*^{F} and *Monitoring*^{P}. *Scent marking*^{F}, which did not have a salient loading on any component in our study, has been suggested to be a contagious behaviour in marmosets (Massen et al., 2016) and so it is not possible to determine whether this behaviour was spontaneous, or triggered by the behaviour of others. Moreover, scent marking might have several functions (Roberts, 2012) and might be affected by sex (French and Cleveland, 1984) or breeding position (Heistermann et al., 1989). *Monitoring*^{P} could have merged several types of scanning as social scanning, curiosity or alertness (Gosselin-Ildari and Koenig, 2012). Therefore, we recommend using indices related to scent marking and monitoring with caution. The context specificity and the true motivation of an animal, however, is not always possible to record during focal behavioural coding (for discussion see Freeman et al., 2011; Iwanicki and Lehmann, 2015; Vazire et al., 2007). To overcome the effect of context it would be necessary either to record the context they occurred in or aggregate those behaviours sufficiently in time by means of longer observation periods (Epstein, 1983).

4.3. Cotton-top tamarin personality model

One set of behaviours that defined Extraversion in tamarins included indices related to physical and social activities. Extraversion in this sense has been described in great apes (Weiss et al., 2009, 2006) and as part of the human Five-Factor Model (McCrae and John, 1992). A second set of behaviours defining cotton-top tamarin Extraversion included indices related to individuals' tendencies to explore their environment. In this way, tamarin Extraversion partly resembled common marmoset Inquisitiveness (Koski et al., 2017) and Openness dimensions (Iwanicki and Lehmann, 2015) identified by questionnaires (for details see Table S19), and Exploration-Avoidance (Koski and Burkart, 2015; Šlipogor et al., 2016) measured by experimental coding. There are three possible reasons why exploratory behaviours were subsumed under cotton-top tamarin Extraversion. First, exploratory behaviours that we observed might be those more connected to physical activity and thus loaded on the same dimension. Second, exploratory behaviour might be rare in stable predictable captive conditions where animals do not have to forage and do not encounter novel stimuli as often. Third, the species-specific socioecology might also play a role. Marmosets live in more diverse habitats than tamarins, and so a distinct Openness dimension in marmosets could reflect an evolved response to spatial variation in habitats (Digby et al., 2006).

Confidence included dominance-related behaviours, low levels of scratching and indices connected to using the space and resources. Tamarin Confidence corresponded to the Assertiveness dimension in one ratings-based study of common marmosets (Koski et al., 2017). It also corresponded to a dimension labelled “Extraversion”, which mainly comprised of dominance-related traits, as described in another study (Iwanicki and Lehmann, 2015) (Table S20). Our results therefore support the general interpretation of dimension, usually labelled as Confidence, Dominance, or Assertiveness as an important part of primate personality that reflects the individuals' need to cope with social interactions and relationships in highly complex social groups.

Many studies have demonstrated that behaviour-based personality models correspond to questionnaire-based models (Garai et al., 2016; Iwanicki and Lehmann, 2015; Konečná et al., 2008; Murray, 2011). This suggests that both methods assess the same underlying constructs. However, the resulting cotton-top tamarin personality model remains to be validated against other personality measures, underlying physiological indicators (e.g. hormones), or other outcomes (e.g. survival or reproductive success).

The fact that we did not obtain further personality dimensions does not necessarily imply that only two personality dimensions characterise tamarin behaviour. Using trait ratings, Iwanicki and Lehmann (2015) and Koski et al. (2017) identified a Conscientiousness dimension in marmosets, which appears to be connected to the advanced socio-cognitive skills necessary for cooperative breeding and therefore it might be an important domain to callitrichids. It is possible that we might have omitted behaviours relevant to Conscientiousness, such as infant care (Delgado and Sulloway, 2017) and other traits otherwise present in questionnaires. Similarly, using controlled experiments it might be possible to assess reactions to novelty or other exploratory tendencies in more detail. For the identification of the whole personality model of a species, we recommend the utilisation of the broader behavioural spectrum and a selection of behaviours relevant to species typical socio-ecology.

5. Conclusion

We described a personality model of cotton-top tamarins, consisting of Extraversion and Confidence. The model corresponds with results of previous studies in primates and can serve as a basis for future comparative personality research in callitrichids. Our findings suggest that common behaviour coding is a useful tool for assessing complex personality structure and may be less time-consuming than previously believed. For cotton-top tamarins, stable personality structure was obtained only after 5 hours of observation per individual. The recommended length of observation in this species can be used as a guide not only in personality studies but also in studies assessing individual variation in behaviour in general. The minimum length of observation recommended in this study for personality assessment should, however, be treated as species-specific before data from other species differing in body size and feeding ecology are tested.

Conflict of interest

Declarations of interest: none

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Appendix A. Supplementary data

References

Addessi, E., Chiarotti, F., Visalberghi, E., 2007. Response to novel food and the role of social influences in common marmosets (*Callithrix jacchus*) and Goeldi's monkeys (*Callimico goeldii*). Am. J. Primatol. 1222, 1210–1222. https://doi.org/10.1002/ajp.20429

Anestis, S.F., 2005. Behavioral style, dominance rank, and urinary cortisol in young chimpanzees (*Pan troglodytes*). Behaviour 142, 1245–1268.

https://doi.org/10.1163/156853905774539418

Bairrão Ruivo, E., Stevenson, M.F., 2017. EAZA Best Practice Guidelines for Callitrichidae. 3.1 Edition. https://www.eaza.net/assets/Uploads/CCC/Callitrichid-BPG-2017-EAZA.PDF (accessed 11 May 2018).

Baldwin, J.D., Baldwin, J.I., 1978. Exploration and Play in Howler Monkeys (*Alouatta palliata*). Primates 19, 411–422. https://doi.org/10.1007/BF02373305

Bell, A.M., Hankison, S.J., Laskowski, K.L., 2009. The repeatability of behaviour: a meta-analysis. Anim. Behav. 77, 771–783. https://doi.org/10.1016/j.anbehav.2008.12.022

Blaszczyk, M.B., 2018. Consistency in social network position over changing environments in a seasonally breeding primate. Behav. Ecol. Sociobiol. 72:11. https://doi.org/10.1007/s00265-017-2425-y

Caperos, J.M., Sánchez, S., Peláez, F., Fidalgo, A., Morcillo, A., 2011. The Effect of Crowding on the Social Behavior of the Cooperatively Breeding Cotton-Top Tamarins (*Saguinus oedipus*). Int. J. Primatol. 32, 1179–1189. https://doi.org/10.1007/s10764-011-9534-7

Carere, C., van Oers, K., 2004. Shy and bold great tits (*Parus major*): body temperature and breath rate in response to handling stress. Physiol. Behav. 82, 905–912. https://doi.org/10.1016/j.physbeh.2004.07.009

Carter, A.J., Feeney, W.E., Marshall, H.H., Cowlishaw, G., Heinsohn, R., 2013. Animal personality: what are behavioural ecologists measuring? Biol. Rev. 88, 465–475. https://doi.org/10.1111/brv.12007

Careau, V., Garland, T., 2012. Performance, Personality, and Energetics: Correlation, Causation, and Mechanism. Physiol. Biochem. Zool. 85, 543–571.

https://doi.org/10.1086/666970

Cattell, R.B., 1966. The scree test for the number of factors. Multivariate Behav. Res. 1, 245-276. https://doi.org/10.1207/s15327906mbr0102_10

Chamove, A.S., Eysenck, H.J., Harlow, H.F., 1972. Personality in monkeys: Factor analyses of rhesus social behaviour. Q. J. Exp. Psychol. 24, 496–504. https://doi.org/10.1080/14640747208400309

Cleveland, J., Snowdon, C.T., 1984. Social Development During the First Twenty Weeks in the Cotton-top Tamarin (*Saguinus o. oedipus*). Anim. Behav. 32, 432–444. https://doi.org/10.1016/S0003-3472(84)80279-1

Coates, A., Poole, T.B., 1983. The Behavior of the Callitrichid Monkey, *Saguinus labiatus labiatus*, in the Laboratory. Int. J. Primatol. 4, 339–371. https://doi.org/10.1007/BF02735599

da Silva, S. do S.B., Ferrari, S.F., 2007. Notes on the reproduction, behaviour and diet of *Saguinus niger* (Primates: Callitrichidae) in a forest remnant at the National Primate Centre, Ananindeua, Pará. Biol. Geral e Exp. 7, 19–28.

Day, R.L., Coe, R.L., Kendal, J.R., Laland, K.N., 2003. Neophilia, innovation and social learning: a study of intergeneric differences in callitrichid monkeys. Anim. Behav. 65, 559–571. https://doi.org/10.1006/anbe.2003.2074

Delgado, M.M., Sulloway, F.J., 2017. Attributes of Conscientiousness Throughout the Animal Kingdom: An Empirical and Evolutionary Overview Mikel. Psychol. Bull. 143, 823–867. https://doi.org/10.1037/bul0000107

Digby, L.J., Ferrari, S.F., Saltzman, W., 2006. Callitrichines: The Role of Competition in Cooperatively Breeding Species, in: Campbell, C., Fuentes, A., MacKinnon, K., Bearder, S., Stumpf, R. (Eds.), Primates in Perspective (1st ed). Oxford University Press, pp. 85–106.

Digman, J.M., 1990. Personality Structure: Emergence of the Five-Factor Model. Annu. Rev. Psychol. 41, 417–440. https://doi.org/10.1146/annurev.ps.41.020190.002221

Dinno, A., 2012. Paran: Horn´s Test of Principial Components/Factors. R package version 1.5.1.

Edwards, L.N., Sorkin, A.E., Rhodes, R.C., Petersson, K.H., 2010. Observational Methods to Measure Behaviors of Captive Cotton-top Tamarins (*Saguinus oedipus*). Zoo Biol. 29, 416–431. https://doi.org/10.1002/zoo.20264

Epstein, S., 1983. Aggregation and beyond: Some basic issues on the prediction of behavior. J. Pers. 51, 360–392. https://doi.org/10.1111/j.1467-6494.1983.tb00338.x

Estrada, A., Juan-Solano, S., Ortíz Martínez, T., Coates-Estrada, R., 1999. Feeding and General Activity Patterns of a Howler Monkey (*Alouatta palliata*) Troop Living in a Forest Fragment at Los Tuxtlas, Mexico. Am. J. Primatol. 48, 167–183. https://doi.org/10.1002/(SICI)1098-2345(1999)48:3<167::AID-AJP1>3.0.CO;2-6

Franks, B., Reiss, D., Cole, P., Friedrich, V., Thompson, N., Higgins, E.T., 2013. Predicting How Individuals Approach Enrichment: Regulatory Focus in Cotton-Top Tamarins (*Saguinus oedipus*). Zoo Biol. 32, 427–435. https://doi.org/10.1002/zoo.21075

Freeman, H.D., Gosling, S.D., Schapiro, S.J., 2011. Comparison of Methods for Assessing Personality in Nonhuman Primates, in: Weiss, A., King, J.E., Murray, L. (Eds.), Personality and Temperament in Nonhuman Primates. Springer, pp. 17–40.

Freeman, H.D., Brosnan, S.F., Hopper, L.M., Lambeth, S.P., Schapiro, S.J., Gosling, S.D., 2013. Developing a Comprehensive and Comparative Questionnaire for Measuring

Personality in Chimpanzees Using a Simultaneous Top-Down/Bottom-Up Design. Am. J. Primatol. 75, 1042–1053. https://doi.org/10.1002/ajp.22168

Freeman, H.D., Gosling, S.D., 2010. Personality in Nonhuman Primates: A Review and Evaluation of Past Research. Am. J. Primatol. 72, 653–671. https://doi.org/10.1002/ajp.20833

French, J.A., Cleveland, J., 1984. Scent-marking in the tamarin, *Saguinus oedipus*: Sex differences and ontogeny. Anim. Behav. 32, 615–623. https://doi.org/10.1016/S0003-3472(84)80299-7

Funder, D.C., 2012. Accurate Personality Judgment. Curr. Dir. Psychol. Sci. 21, 177–182. https://doi.org/10.1177/0963721412445309

Garai, C., Weiss, A., Arnaud, C., Furuichi, T., 2016. Personality in Wild Bonobos (*Pan paniscus*). Am. J. Primatol. 78, 1178–1189. https://doi.org/10.1002/ajp.22573

Ginther, A.J., Snowdon, C.T., 2009. Expectant parents groom adult sons according to previous alloparenting in a biparental cooperatively breeding primate. Anim. Behav. 78, 287–297. https://doi.org/10.1016/j.anbehav.2009.04.020

Gosling, S.D., 2001. From Mice to Men: What Can We Learn About Personality From Animal Research? Psychol. Bull. 127, 45–86. https://doi.org/10.1037//0033-2909.127.1.45

Gosling, S.D., John, O.P., 1999. Personality Dimensions in Nonhuman Animals: A Cross-Species Review. Curr. Dir. Psychol. Sci. 8, 69–75. https://doi.org/10.1111/1467-8721.00017

Gosselin-Ildari, A.D., Koenig, A., 2012. The Effects of Group Size and Reproductive Status on Vigilance in Captive *Callithrix jacchus*. Am. J. Primatol. 74, 613–621.

https://doi.org/10.1002/ajp.22013

Heistermann, M., Kleis, E., Prove, E., Wolters, H.-J., 1989. Fertility Status, Dominance, and Scent Marking Behavior of Family-Housed Female Cotton-Top Tamarins (*Saguinus oedipus*) in Absence of Their Mothers. Am. J. Primatol. 18, 177–189. https://doi.org/10.1002/ajp.1350180302

Holm, S., 1979. A Simple Sequentially Rejective Multiple Test Procedure. Scand. J. Stat. 6, 65–70. http://www.jstor.org/stable/4615733

Horn, J.L., 1965. A rationale and test for the number of factors in factor analysis. Psychometrika 30, 179–185. https://doi.org/10.1007/BF02289447

Huntingford, F.A., 1976. The relationship between anti-predator behavior and aggression among conspecifics in the three-spined stickleback, *Gasterosteus aculeatus*. Anim. Behav. 24, 245–260. https://doi.org/10.1016/S0003-3472(76)80034-6

Itoh, K., 2002. Personality Research with Non-human Primates: Theoretical Formulation and Methods. Primates 43, 249–261. https://doi.org/10.1007/BF02629652

Iwanicki, S., Lehmann, J., 2015. Behavioral and Trait Rating Assessments of Personality in Common Marmosets (*Callithrix jacchus*). J. Comp. Psychol. 129, 205–217. https://doi.org/10.1037/a0039318

Jung, S., Lee, S., 2011. Exploratory factor analysis for small samples. Behav. Res. Methods 43, 701–709. https://doi.org/10.3758/s13428-011-0077-9

Kanda, L.L., Louon, L., Straley, K., 2012. Stability in Activity and Boldness Across Time and Context in Captive Siberian Dwarf Hamsters. Ethology 118, 518–533. https://doi.org/10.1111/j.1439-0310.2012.02038.x

Kawanaka, K., 1996. Observation Time and Sampling Intervals for Measuring Behavior and

Interactions of Chimpanzees in the Wild. Primates 37, 185–196. https://doi.org/10.1007/BF02381406

Knox, K.L., Sade, D.S., 1991. Social Behavior of the Emperor Tamarin in Captivity: Components of Agonistic Display and the Agonistic Network. Int. J. Primatol. 12, 439–480. https://doi.org/10.1007/BF02547634

Konečná, M., Lhota, S., Weiss, A., Urbánek, T., Adamová, T., Pluháček, J., 2008. Personality in Free-Ranging Hanuman Langur (*Semnopithecus entellus*) Males: Subjective Ratings and Recorded Behavior. J. Comp. Psychol. 122, 379–389. https://doi.org/10.1037/a0012625

Konečná, M., Weiss, A., Lhota, S., Wallner, B., 2012. Personality in Barbary macaques (*Macaca sylvanus*): Temporal stability and social rank. J. Res. Pers. 46, 581–590. https://doi.org/10.1016/j.jrp.2012.06.004

Koski, S.E., 2014. Broader horizons for animal personality research. Front. Ecol. Evol. 2, 70. https://doi.org/10.3389/fevo.2014.00070

Koski, S.E., 2011a. How to Measure Animal Personality and Why Does It Matter? Integrating the Psychological and Biological Approaches to Animal Personality., in: Inoue-Murayama, M., Kawamura, S., Weiss, A. (Eds.), From Genes to Animal Behavior. Springer Japan, pp. 115–136. https://doi.org/10.1007/978-4-431-53892-9_5

Koski, S.E., 2011b. Social personality traits in chimpanzees: temporal stability and structure of behaviourally assessed personality traits in three captive populations. Behav. Ecol. Sociobiol. 65, 2161–2174. https://doi.org/10.1007/s00265-011-1224-0

Koski, S.E., Buchanan-Smith, H.M., Burkart, J.M., Bugnyar, T., Weiss, A., 2017. Common Marmoset (*Callithrix jacchus*) Personality. J. Comp. Psychol. 131, 326–336.

https://doi.org/10.1037/com0000089

Koski, S.E., Burkart, J.M., 2015. Common marmosets show social plasticity and group-level similarity in personality. Sci. Rep. 5, 8878. https://doi.org/10.1038/srep08878

Lorenzo-Seva, U., ten Berge, J.M.F., 2006. Tucker's Congruence Coefficient as a Meaningful Index of Factor Similarity. Methodology 2, 57–64. http://dx.doi.org/10.1027/1614-2241.2.2.57

Martin, P., Bateson, P., 2007. Measuring Behaviour: An Introductionary Guide (3rd ed). Cambridge University Press.

Masi, S., Cipolletta, C., Robbins, M.M., 2009. Western Lowland Gorillas (*Gorilla gorilla gorilla*) Change Their Activity Patterns in Response to Frugivory. Am. J. Primatol. 71, 91–100. https://doi.org/10.1002/ajp.20629

Massen, J.J.M., Šlipogor, V., Gallup, A.C., 2016. An Observational Investigation of Behavioral Contagion in Common Marmosets (*Callithrix jacchus*): Indications for Contagious Scent-Marking. Front. Psychol. 7, 1190. https://doi.org/10.3389/fpsyg.2016.01190

McCrae, R.R., John, O.P., 1992. An Introduction to the Five-Factor Model and Its Applications. J. Pers. 60, 175–215. https://doi.org/10.1111/j.1467-6494.1992.tb00970.x

McCrae, R.R., Zonderman, A.B., Costa, P.T., Bond, M.H., Paunonen, S. V., 1996. Evaluating Replicability of Factors in the Revised NEO Personality Inventory: Confirmatory Factor Analysis Versus Procrustes Rotation. J. Pers. Soc. Psychol. 70, 552–566. https://doi.org/10.1037/0022-3514.70.3.552

Murray, L., 2011. Predicting Primate Behavior from Personality Ratings, in: Weiss, A., King, J.E., Murray, L. (Eds.), Personality and Temperament in Nonhuman Primates. Springer, pp. 129–168.

Nakagawa, S., Schielzeth, H., 2010. Repeatability for Gaussian and non-Gaussian data: A practical guide for biologists. Biol. Rev. 85, 935–956. https://doi.org/10.1111/j.1469-185X.2010.00141.x

Neumann, C., Agil, M., Widdig, A., Engelhardt, A., 2013. Personality of Wild Male Crested Macaques (*Macaca nigra*). PLoS One 8, e69383. https://doi.org/10.1371/journal.pone.0069383

Nyström, P., Schapiro, S.J., Hau, J., 2001. Accumulated Means Analysis: A Novel Method to Determine Reliability of Behavioral Studies Using Continuous Focal Sampling. In Vivo 15, 29–34. PMID: 11286125

Pederson, A.K., King, J.E., Landau, V.I., 2005. Chimpanzee (*Pan troglodytes*) personality predicts behavior. J. Res. Pers. 39, 534–549. https://doi.org/10.1016/j.jrp.2004.07.002

Peñate, L., Peláez, F., Sánchez, S., 2009. Reconciliation in Captive Cotton-top Tamarins (*Saguinus oedipus*), a Cooperative Breeding Primate. Am. J. Primatol. 71, 895–900. https://doi.org/10.1002/ajp.20721

Perals, D., Griffin, A.S., Bartomeus, I., Sol, D., 2017. Revisiting the open-field test: what does it really tell us about animal personality? Anim. Behav. 123, 69–79. https://doi.org/10.1016/j.anbehav.2016.10.006

Price, E.C., 1991. Competition to Carry Infants in Captive Families of Cotton-Top Tamarins (*Saguinus oedipus*). Behaviour 118, 66–88. https://doi.org/10.1163/156853991X00201

Réale, D., Reader, S.M., Sol, D., McDougall, P.T., Dingemanse, N.J., 2007. Integrating animal temperament within ecology and evolution. Biol. Rev. 82, 291–318. https://doi.org/10.1111/j.1469-185X.2007.00010.x

Revelle, M.W., 2017. Procedures for Psychological, Psychometric, and Personality Research. R package version 1.7.5.

Roberts, S.C., 2012. On the Relationship between Scent-Marking and Territoriality in Callitrichid Primates. Int. J. Primatol. 33, 749–761. https://doi.org/10.1007/s10764-012-9604-5

Robinson, L.M., Coleman, K., Capitanio, J.P., Gottlieb, D.H., Handel, I.G., Adams, M.J., Leach, M.C., Waran, N.K., Weiss, A., 2018. Rhesus macaque personality, dominance, behavior, and health. Am. J. Primatol. 80. https://doi.org/10.1002/ajp.22739

Shannon, C.E., Weaver, W., 1963. The mathematical theory of communication. University Illinois Press, Champaign.

Schuster, A.C., Carl, T., Foerster, K., 2017. Repeatability and consistency of individual behaviour in juvenile and adult Eurasian harvest mice. Sci. Nat. 104:10. https://doi.org/10.1007/s00114-017-1430-3

Sih, A., Bell, A., Johnson, J.C., 2004. Behavioral syndromes: an ecological and evolutionary overview. Trends Ecol. Evol. 19, 372–378. https://doi.org/10.1016/j.tree.2004.04.009

Snowdon, C.T., Pickhard, J.J., 1999. Family Feuds: Severe Aggression among Cooperatively Breeding Cotton-Top Tamarins. Int. J. Primatol. 20, 651–663. https://doi.org/10.1023/A:1020796517550

Stanley, C.R., Mettke-Hofmann, C., Preziosi, R.F., 2017. Personality in the cockroach *Diploptera punctata*: Evidence for stability across developmental stages despite age effects on boldness. PLoS One 12, e0176564. https://doi.org/10.1371/journal.pone.0176564

Stevenson-Hinde, J., Stillwell-Barnes, R., Zunz, M., 1978. Subjective Assessment of

Individual Rhesus Monkeys monkeys. Primates 19, 473–482. https://doi.org/10.1007/BF02373309

Stoffel, M., Nakagawa, S., Schielzeth, H., 2017. Repeatability Estimation for Gaussian and Non-Gaussian Data. R package version 0.9.2.

Sussman, A.F., Ha, J.C., Bentson, K.L., Crockett, C.M., 2013. Temperament in Rhesus, Long-Tailed, and Pigtailed Macaques Varies by Species and Sex. Am. J. Primatol. 75, 303–313. https://doi.org/10.1002/ajp.22104

Sussman, A.F., Mates, E.A., Ha, J.C., Bentson, K.L., Crockett, C.M., 2014. Tenure in current captive setting and age predict personality changes in adult pigtailed macaques. Anim. Behav. 89, 23–30. https://doi.org/10.1016/j.anbehav.2013.12.009

Šlipogor, V., Gunhold-de Oliveira, T., Tadić, Z., Massen, J.J.M., Bugnyar, T., 2016. Consistent Inter-Individual Differences in Common Marmosets (*Callithrix jacchus*) in Boldness-Shyness, Stress-Activity, and Exploration-Avoidance. Am. J. Primatol. 78, 961–973. https://doi.org/10.1002/ajp.22566

Vazire, S., Gosling, S.D., Dickey, A.S., Schapiro, S.J., 2007. Measuring personality in nonhuman animals, in: Robins, R.W., Fraley, R.C., Krueger, R.F. (Eds.), Handbook of Research Methods in Personality Psychology. The Guilford Press, New York, pp. 190–206.

Vogt, J.L., 1978. The Social Behavior of a Marmoset (*Saguinus fuscicollis*) Group II: Behavior Patterns and Social Interaction. Primates 19, 287–300. https://doi.org/10.1007/BF02382798

Weiss, A., 2017. A human model for primate personality. Proc. R. Soc. B 284, 20171129. https://doi.org/10.1098/rspb.2017.1129

Weiss, A., Adams, M.J., 2013. Differential Behavioral Ecology: The Structure, Life History, and Evolution of Primate Personality, in: Carere, C., Maestripieri, D. (Eds.), Animal Personalities: Behavior, Physiology, and Evolution. University of Chicago Press, pp. 96–123.

Weiss, A., Adams, M.J., Widdig, A., Gerald, M.S., 2011. Rhesus Macaques (*Macaca mulatta*) as Living Fossils of Hominoid Personality and Subjective Well-Being. J. Comp. Psychol. 125, 72–83. https://doi.org/10.1037/a0021187

Weiss, A., Inoue-Murayama, M., Hong, K.W., Inoue, E., Udono, T., Ochiai, T., Matsuzawa, T., Hirata, S., King, J.E., 2009. Assessing Chimpanzee Personality and Subjective Well-Being in Japan. Am. J. Primatol. 71, 283–292. https://doi.org/10.1002/ajp.20649

Weiss, A., King, J.E., Perkins, L., 2006. Personality and Subjective Well-Being in Orangutans (*Pongo pygmaeus* and *Pongo abelii*). J. Pers. Soc. Psychol. 90, 501–511. https://doi.org/10.1037/0022-3514.90.3.501

Whitham, W., Washburn, D.A., 2017. A History of Animal Personality Research, in: Vonk, J., Weiss, A., Kuczaj, S.A. (Eds.), Personality in Nonhuman Animals. Springer, Cham, Switzerland, pp. 3–16.

Wilson, A.D.M., Godin, J.-G.J., Ward, A.J.W., 2010. Boldness and Reproductive Fitness Correlates in the Eastern Mosquitofish, *Gambusia holbrooki*. Ethology 116, 96–104. https://doi.org/10.1111/j.1439-0310.2009.01719.x

Zwick, W.R., Velicer, W.F., 1986. Comparison of Five Rules for Determining the Number of Components to Retain. Psychol. Bull. 99, 432–442. https://doi.org/10.1037/0033-2909.99.3.432

Supplementary data for: How long does it take? Reliable personality assessment based on common behaviour in cotton-top tamarins *(Saguinus oedipus)*

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Table S1. Ethogram of cotton-top tamarin *(Saguinus oedipus)*

Behavioural category	Behaviour	Description
Continuous focal sampling		
Locomotion	**Move**	horizontal or vertical movement of more than 50 cm; including walking running and climbing; excluding chasing and playing
	Jump	focal individual jumps to overcome gaps between substrates in the enclosure (i.e. branches, trunks, shelves, walls, …); including change of substrate
	Resting	sitting or lying in relaxed position with closed eyes; individual may be in proximity or contact with other individual
Food interactions	**Eating**	handling, chewing and active ingestion of food by swallowing it
	Drinking	ingestion of liquids by drinking from water bowl/dispenser, licking wet surfaces or hands dipped in water
	Floor scanning	visual inspection of ground in order to find food; individual might be on the ground or on substrate above the ground
	Prey catching	catching invertebrates moving freely in the enclosure
	Prey catching - attempt	unsuccessful attempt to catch invertebrates moving freely in the enclosure
	Taking food from keeper	individual takes food from the zookeeper's hand
	Approach – food	oriented approach towards individual possessing food item
	Contact - food	initiation of contact with individual possessing food item
	Follow – food	individual follows the movement of another individual that possesses food to its proximity
	Co-feeding	joining other individual eating from the same feeding bowl
	Carrying food away	taking food away from feeding bowl where other individual is eating

	Begging	scrounging the food from individual that is eating by fixing the food item with sight; may involve characteristic vocalization (squeak), touching or attempting to take the food item
	Sharing food	voluntary sharing of food item with other individual resulting in eating together the same food item the possessor holds in hand or yielding the food item; often after begging
	Stealing food	taking food from other individual's hand or mouth
	Stealing food - attempt	unsuccessful attempt to steal food from hand or mouth of other individual
Object interactions	Attention	individual fixes its stare to the object of interest to examine it; usually followed by moving in direction of object
	Surface licking	individual licks surface of substrate
	Substrate searching	sitting on the ground and looking for the food in the substrate by using hands
	Object manipulation	manipulation with object (e.g. twigs, leaves, bark; excluding food) using hands or mouth; including looking at, sniffing and biting into the object
	General exploration	manipulative investigation of objects, enrichment or equipment of enclosure using hands or mouth
	Approach - object	oriented approach towards individual possessing object of interest
	Contact – object	initiation of contact with individual possessing object of interest
	Follow - object	individual follows the movement of another individual that possesses object to its proximity
	Stealing object	taking an object (e.g. twig, leaf, bark) from individual possessing it
	Stealing object - attempt	unsuccessful attempt to possess an object that is hold by other individual
Comfort	**Scratching**	rapid rubbing of body using the claws of hand or foot; individual does not have to be visually focused on the scratched area
	Face scratching	rubbing muzzle with hand

	Self-grooming	using claws of hands or mouth to pick through its own skin or fur; including removing of particles; individual is visually focused on the groomed area
	Stretching	stretching of entire body or limbs
Olfactory	**Object sniffing**	smelling the surface of substrate, objects, scent marks or food
	Sniffing individual	smelling the body, face or anogenital region of other individual
	Muzzle rubbing	pressing the oro-facial region onto the substrate and rubbing it with movements of head
	Scent marking	rubbing the anogenital area against the substrate in a sitting position or the suprapubic pad or sternal area either by pulling itself forward with hands or pushing with legs; may be accompanied by urine discharge
	Allomarking	scent marking over the body of another individual that can carry infants
	Urine tasting	individual licks urine drops of another individual either left on substrate or while the individual is urinating or scent marking
Play	**Solitary play**	repeated jumping and falling from one branch to another, swinging and bouncing on branches; excluding play with object
	Play with object	manipulation or biting into an object in the context of play
	Social play	non-aggressive and active interaction of 2 or more individuals, including play chasing, play wrestling, displaying, repeated jumping/ falling from one branch to another together with others
	Joining the play	individual engages in ongoing social play of other individuals
	Solicit play	attempt to attract the attention and involve other individual in playing; including tongue flicking, staring, pushing the individual or jumping in front of the individual
Affiliative	**Proximity**	individual is in the distance of max. 30 cm from other individual
	Contact	individual is in body contact with another or in the comfortable reach of arm (<9 cm)

	Allogrooming	individual picks slowly through the fur or skin of other individual using the claws of 1 or both hands or mouth; including removing particles
	Invite grooming	individual lowers its body or stretches out on its back or side requesting grooming
	Nuzzling	individual gently rubs its muzzle against other individual; may be accompanied by sniffing and licking
	Kiss	muzzle-muzzle contact of 2 animals; may involve tongue flicking
	Arm over	placing arm around other individual’s upper body or shoulders
	Waist clasping	placing both arms from behind around other individual’s waist
	Huddling	animal lies across or sits or lies next to other individual in tight body contact; limbs can be intertwined
Sexual	Copulation	male mounts a female, including penile insertion and thrusting, sometimes accompanied by tongue flicking
	Mounting	individual gets on back of other individual with arms around its waist; may include pelvic thrusts and tongue flicking
Infant care	Climb on	infant climbs on the back or side of potential carrier (from substrate or another carrier); limbs of infant are not in the contact with substrate; initiative of infant
	Climb off	infant climbs from the carrier to substrate or another carrier
	Solicit carrying	infant approaches potential carrier trying to climb on its back squeaking; potential carrier is not interested
	Invitation to carry	potential carrier attempts to entice the infant in order to carry it; including tongue flicking or lowering its body
	Taking infant on	potential carrier gathers infant from substrate or back of current carrier in order to carry it; initiative of potential carrier
	Taking infant on – attempt	unsuccessful attempt of potential carrier to gather infant from substrate or back of the current carrier in order to carry it; infant refuses to climb on or the carrier refuses to transfer the infant; sometimes resulting in aggression between caretakers

	Infant rejection	caretaker dislodges infant clinging to it or prevents infant to climb on by using scratching, biting, pushing, pulling infant's extremities or rolling the infant against substrate
	Infant rejection - attempt	unsuccessful attempt to dislodge infant from back or prevent infant to climb on
	Nursing	infant is from the ventral side of the female suckling; infant's mouth is on the nipple of female
Dominance	**Grimace**	lip corners are pulled back, lower lip is retracted so the mouth is slightly open revealing dentition with pressed jaws; accompanied by vocalization
	Avoiding	individual while travelling changes the direction of its move in order to avoid another individual
	Grasp	individual places its arm over the other individual's shoulder, head, upper body or touches other individual's face in dominant manner while slightly raising its body or head
	Displacement	individual chases other individual away from potential source, e.g. food, water, sleeping box
Agonistic non-contact	**Facial threat**	staring and frowning at other individual, may involve tongue or ear flicking
	Open mouth display	individual stares at another with mouth widely open exposing its teeth
	Headshake	rapid turning of head from side to side; might be accompanied by teeth chattering
	Body display	individual stares at other individual, limbs flexed, vertebral column bent into high arch, fur piloerected; often accompanied by facial threat; individual might be moving or vocalizing
	Chase	chasing other individual that is fleeing and trying to hide; rapid locomotion
Agonistic contact	**Face pressing**	individual grabs the head of other individual and presses its open mouth to oponent's mouth
	Bite	individual bites another individual with its teeth; teeth may or may not penetrate the skin
	Push	individual aggressively hits other individual using its hand; may push the other animal away

	Grab	individual grabs hair of other individual; may pull out strand of hair
	Beating	repeated pushing and hitting other individual using arms; other individual usually beats back
	Fight	aggressive physical confrontation of individuals; short fast struggle involving biting, wrestling, hitting, scratching, kicking; victim may scream
	General aggression	any fast aggressive act of behaviour that observer was not able to register in detail
Other	**Alert**	vigilant observing of environment; individual is stationary and may turn its head from side to side
	General alarm	individual vocalizes (Type E or H chirp) when startled or frightened
	Vomiting	throwing up, usually after eating insect
	Head twist	stereotypic behaviour when individual stretches its head by tilting it back
	Out of sight	individual disappears from sight of observer to the box or separate part of enclosure
Other social	**Approach**	individual comes in proximity to other individual
	Departure	leaving from contact or proximity of other individual; excluding fleeing or displacement
	Following	individual follows the movement of other individual to its proximity
	Attention to other	fixed gaze at individual of interest; in context of hostility or curiosity
	Tongue flick	protrusion and rapid rhythmical movements of the tongue tip up and down; in sexual, aggressive or infant care context
	Teeth cleaning	individual uses its hands to open mouth of other individual and clean its teeth by using tongue; does not usually last long as groomee tries to recoil; often followed by aggression from groomee
	Terminate grooming	individual ends the allogrooming

Instantaneous focal sampling

Substrate type	**Branch**	branch or stem of a tree or bush; excluding vertical stems
	Trunk	vertical trunk or stem of any diameter
	Sleeping box	nesting box providing shelter
	Shelf	horizontal surfaces wider and longer than 10 cm, e.g. shelves, top of sleeping box
	Ground	floor of the enclosure
	Wall	vertical wall (wire mesh, artificial rockwork) of enclosure enabling clinging and locomotion
	Ceiling	roof or ceiling of enclosure enabling hanging or moving
	Other	other equipment of enclosure, e.g. ropes, pipes, toys, enrichment
Locomotion/ postures	**Move**	
	Jump	
	Sitting	individual is in stationary position sitting on horizontal substrate
	Lying	individual places its body in horizontal position, with both limbs hanging down or rested; on horizontal or slightly inclined substrate
	Clinging	individual hangs on tightly to vertical substrate using claws of both hands and feet (i.e. wire mesh, wall, large tree trunks)
	Hanging	individual is suspended from wire mesh ceiling of enclosure or branch holding on using all limbs or legs
	Resting	
Food interactions	**Eating**	
	Drinking	
	Co-feeding	
Object interactions	**Substrate searching**	
	Object manipulation	

	General exploration	
	Play with object	
Social interactions	**Social play**	
	Allogrooming	
	Proximity	
	Contact	
Other	**Solitary play**	
	Self-grooming	
	Looking	individual is stationary and calmly looks around
	Watching	individual observes particular object, place, animal or person
	Alert	

Table S2. Repeatability estimates of behavioural indices across three time blocks

	R ± SE	95% CI	*p*
Approaches(in)[F]	0.93 ± 0.04	[0.83, 0.96]	0.001
Departures(in)[F]	0.93 ± 0.03	[0.85, 0.97]	0.001
Substrate diversity[S]	0.88 ± 0.05	[0.75, 0.94]	0.001
Affiliation[P]	0.84 ± 0.06	[0.67, 0.92]	0.001
Scratching[F]	0.82 ± 0.07	[0.64, 0.91]	0.001
Scent marking[F]	0.79 ± 0.08	[0.60, 0.89]	0.001
Exploration[F]	0.77 ± 0.08	[0.57, 0.88]	0.001
Object sniffing[F]	0.77 ± 0.08	[0.57, 0.88]	0.001
Contact aggression(in)[F]	0.76 ± 0.09	[0.54, 0.88]	0.001
Carrying food away(in)[F]	0.73 ± 0.10	[0.47, 0.86]	0.001
Resting[P]	0.73 ± 0.09	[0.51, 0.85]	0.001
Activity diversity[S]	0.69 ± 0.10	[0.44, 0.83]	0.001
Grimace[F]	0.69 ± 0.10	[0.43, 0.82]	0.001
Monitoring[P]	0.63 ± 0.12	[0.35, 0.79]	0.001
Threats(in)[F]	0.60 ± 0.12	[0.32, 0.77]	0.001

Vigilance^F	0.51 ± 0.13	[0.19, 0.71]	0.001
Passive affiliation^P	0.45 ± 0.14	[0.15, 0.67]	0.002
Invite grooming(in)^F	0.37 ± 0.14	[0.07, 0.62]	0.004
Grooming(in)^F	0.29 ± 0.14	[0, 0.54]	0.02
Self-grooming^F	0.28 ± 0.14	[0, 0.55]	0.02
Grooming(rec)^F	0.26 ± 0.15	[0, 0.55]	0.03
Terminate grooming^F	0.26 ± 0.14	[0, 0.53]	0.03
Invite grooming(rec)^F	0.25 ± 0.14	[0, 0.52]	0.04

Note. P = index based on proportion of time, S = index computed as Shannon diversity index, F = index calculated as frequency, (in) = behaviour initiated by focal individual, (rec) = behaviour received by focal individual.

Table S3. Full model. Varimax rotated solution of REFA

	Component		
Behavioural index	F1	F2	Communalities
Activity diversity^S	**0.86**	0.28	0.81
Passive affiliation^P	**-0.85**	0.09	0.73
Threats(in)^F	**0.84**	-0.05	0.72
Exploration^F	**0.84**	0.00	0.71
Vigilance^F	**0.69**	**-0.40**	0.64
Grooming(in)^F	**0.68**	**0.33**	0.57
Invite grooming(rec)^F	**0.65**	0.04	0.43
Resting^P	**-0.61**	**-0.42**	0.54
Terminate grooming^F	**0.61**	**0.39**	0.53
Grimace^F	**0.57**	-0.11	0.33
Object sniffing^F	**0.47**	**-0.32**	0.33
Monitoring^P	**0.41**	-0.08	0.17
Self-grooming^F	**0.39**	-0.21	0.19
Scent marking^F	**0.32**	0.09	0.11
Departures(in)^F	-0.16	**0.88**	0.80
Approaches(in)^F	-0.06	**0.81**	0.66
Scratching^F	-0.11	**-0.80**	0.65
Affiliation^P	-0.24	**0.76**	0.64
Contact aggression(in)^F	-0.05	**0.73**	0.53
Carrying food away(in)^F	-0.16	**0.62**	0.41
Grooming(rec)^F	0.05	**0.59**	0.35
Substrate diversity^S	0.29	**0.55**	0.39

Invite grooming(in)^F	0.20	**0.43**	0.23
Explained variability	27%	23%	

Note. N = 20. Factor loadings ≥ |0.3| are considered salient and indicated in bold-face.

Table S4. Promax rotated solution of PCA and the component correlation: full model

	Component		
Behavioural index	PC1	PC2	Communalities
Activity diversity^S	**0.90**	0.22	0.87
Exploration^F	**0.88**	-0.07	0.77
Passive affiliation^P	**-0.88**	0.16	0.79
Threats(in)^F	**0.88**	-0.13	0.77
Grooming(in)^F	**0.72**	0.29	0.62
Vigilance^F	**0.70**	**-0.47**	0.69
Invite grooming(rec)^F	**0.68**	-0.02	0.46
Terminate grooming^F	**0.65**	0.36	0.58
Resting^P	**-0.65**	-0.39	0.59
Grimace^F	**0.58**	-0.16	0.36
Object sniffing^F	**0.48**	-0.38	0.36
Monitoring^P	**0.42**	-0.12	0.19
Self-grooming^F	0.39	-0.25	0.21
Scent marking^F	0.34	0.07	0.12
Departures(in)^F	-0.13	**0.93**	0.88
Approaches(in)^F	-0.03	**0.85**	0.72
Scratching^F	-0.15	**-0.83**	0.72
Affiliation^P	-0.22	**0.81**	0.70
Contact aggression(in)^F	-0.02	**0.76**	0.58
Carrying food away(in)^F	-0.14	**0.66**	0.45
Grooming(rec)^F	0.08	**0.61**	0.38
Substrate diversity^S	0.32	**0.55**	0.42
Invite grooming(in)^F	0.23	**0.43**	0.25
Explained variability	29%	25%	

Note. The correlation of components was 0.04. Tables S4 – S18: N = 20. Salient loadings ≥ |0.4| are in bold-face.

Table S5. Varimax rotated solution of PCA: 14-hour model

	Component		
Behavioural index	PC1	PC2	Communalities

Activity diversity^{S}	**0.89**	0.27	0.86
Exploration^{F}	**0.87**	0.00	0.76
Passive affiliation^{P}	**-0.87**	0.12	0.78
Threats(in)^{F}	**0.87**	-0.05	0.76
Vigilance^{F}	**0.72**	**-0.41**	0.69
Grooming(in)^{F}	**0.72**	0.33	0.63
Invite grooming(rec)^{F}	**0.71**	0.07	0.50
Terminate grooming^{F}	**0.66**	0.38	0.58
Resting^{P}	**-0.61**	**-0.43**	0.56
Grimace^{F}	**0.58**	-0.12	0.35
Object sniffing^{F}	**0.49**	-0.31	0.34
Self-grooming^{F}	**0.47**	-0.21	0.27
Monitoring^{P}	**0.44**	-0.14	0.21
Scent marking^{F}	0.35	0.09	0.13
Departures(in)^{F}	-0.17	**0.91**	0.86
Scratching^{F}	-0.11	**-0.86**	0.75
Approaches(in)^{F}	-0.09	**0.82**	0.68
Affiliation^{P}	-0.24	**0.80**	0.70
Contact aggression(in)^{F}	-0.08	**0.74**	0.56
Grooming(rec)^{F}	0.09	**0.62**	0.40
Carrying food away(in)^{F}	-0.19	**0.62**	0.42
Substrate diversity^{S}	0.29	**0.59**	0.43
Invite grooming(in)^{F}	0.20	**0.49**	0.28
Explained variability	30%	24%	

Table S6. Varimax rotated solution of PCA: 13-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Activity diversity^{S}	**0.89**	0.25	0.86
Threats(in)^{F}	**0.88**	-0.07	0.78
Exploration^{F}	**0.88**	-0.06	0.77
Passive affiliation^{P}	**-0.87**	0.08	0.76
Vigilance^{F}	**0.72**	**-0.41**	0.68
Grooming(in)^{F}	**0.70**	0.36	0.63
Invite grooming(rec)^{F}	**0.65**	0.09	0.44
Resting^{P}	**-0.63**	**-0.41**	0.56
Terminate grooming^{F}	**0.63**	**0.45**	0.59

Grimace^F	**0.55**	-0.14	0.32
Object sniffing^F	**0.51**	-0.28	0.34
Self-grooming^F	**0.47**	-0.20	0.26
Monitoring^P	**0.46**	-0.16	0.24
Scent marking^F	0.33	0.09	0.12
Departures(in)^F	-0.19	**0.91**	0.87
Scratching^F	-0.10	**-0.87**	0.76
Approaches(in)^F	-0.09	**0.83**	0.69
Affiliation^P	-0.26	**0.79**	0.70
Contact aggression(in)^F	-0.07	**0.74**	0.56
Grooming(rec)^F	0.02	**0.63**	0.39
Carrying food away(in)^F	-0.20	**0.61**	0.42
Substrate diversity^S	0.28	**0.59**	0.43
Invite grooming(in)^F	0.15	**0.47**	0.25
Explained variability	29%	25%	

Table S7. Varimax rotated solution of PCA: 12-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Activity diversity^S	**0.89**	0.24	0.86
Passive affiliation^P	**-0.88**	0.08	0.78
Exploration^F	**0.88**	-0.07	0.78
Threats(in)^F	**0.88**	-0.03	0.77
Grooming(in)^F	**0.74**	0.36	0.67
Vigilance^F	**0.71**	**-0.41**	0.67
Terminate grooming^F	**0.66**	**0.45**	0.64
Invite grooming(rec)^F	**0.64**	0.09	0.42
Resting^P	**-0.61**	**-0.40**	0.54
Grimace^F	**0.54**	-0.13	0.31
Object sniffing^F	**0.51**	-0.26	0.33
Self-grooming^F	**0.48**	-0.19	0.26
Monitoring^P	**0.48**	-0.13	0.24
Scent marking^F	0.30	0.09	0.10
Departures(in)^F	-0.19	**0.92**	0.88
Scratching^F	-0.12	**-0.84**	0.73
Approaches(in)^F	-0.09	**0.83**	0.70
Affiliation^P	-0.26	**0.79**	0.70

Contact aggression(in)[F]	-0.06	**0.75**	0.57
Grooming(rec)[F]	0.07	**0.64**	0.42
Substrate diversity[S]	0.25	**0.57**	0.39
Carrying food away(in)[F]	-0.21	**0.56**	0.36
Invite grooming(in)[F]	0.16	**0.48**	0.25
Explained variability	29%	25%	

Table S8. Varimax rotated solution of PCA: 11-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Activity diversity[S]	**0.89**	0.25	0.85
Threats(in)[F]	**0.88**	-0.02	0.77
Exploration[F]	**0.85**	-0.03	0.72
Passive affiliation[P]	**-0.83**	0.08	0.70
Grooming(in)[F]	**0.70**	**0.41**	0.66
Vigilance[F]	**0.69**	**-0.42**	0.66
Resting[P]	**-0.64**	-0.37	0.55
Invite grooming(rec)[F]	**0.62**	0.13	0.40
Terminate grooming[F]	**0.62**	**0.51**	0.64
Object sniffing[F]	**0.57**	-0.24	0.38
Grimace[F]	**0.49**	-0.14	0.26
Monitoring[P]	**0.46**	-0.10	0.23
Self-grooming[F]	**0.46**	-0.19	0.25
Scent marking[F]	0.35	0.10	0.13
Departures(in)[F]	-0.19	**0.92**	0.88
Approaches(in)[F]	-0.10	**0.84**	0.71
Scratching[F]	-0.11	**-0.83**	0.70
Affiliation[P]	-0.28	**0.78**	0.68
Contact aggression(in)[F]	-0.07	**0.75**	0.56
Grooming(rec)[F]	0.07	**0.67**	0.45
Substrate diversity[S]	0.25	**0.56**	0.38
Carrying food away(in)[F]	-0.18	**0.56**	0.34
Invite grooming(in)[F]	0.19	**0.51**	0.29
Explained variability	28%	25%	

Table S9. Varimax rotated solution of PCA: 10-hour model

Behavioural index	Component PC1	PC2	Communalities
Activity diversity^{S}	**0.89**	0.24	0.85
Threats(in)^{F}	**0.85**	-0.03	0.72
Passive affiliation^{P}	**-0.83**	0.09	0.69
Exploration^{F}	**0.79**	-0.04	0.63
Grooming(in)^{F}	**0.74**	0.39	0.70
Terminate grooming^{F}	**0.66**	**0.49**	0.67
Vigilance^{F}	**0.65**	**-0.45**	0.62
Invite grooming(rec)^{F}	**0.62**	0.22	0.44
Resting^{P}	**-0.60**	-0.36	0.49
Object sniffing^{F}	**0.54**	-0.30	0.38
Grimace^{F}	**0.50**	-0.15	0.27
Self-grooming^{F}	**0.48**	-0.11	0.24
Monitoring^{P}	**0.42**	-0.07	0.18
Scent marking^{F}	0.37	0.05	0.14
Departures(in)^{F}	-0.22	**0.91**	0.88
Approaches(in)^{F}	-0.13	**0.82**	0.70
Scratching^{F}	-0.16	**-0.81**	0.67
Affiliation^{P}	-0.25	**0.75**	0.63
Contact aggression(in)^{F}	-0.12	**0.71**	0.52
Grooming(rec)^{F}	0.13	**0.67**	0.46
Carrying food away(in)^{F}	0.10	**0.60**	0.37
Invite grooming(in)^{F}	0.20	**0.56**	0.35
Substrate diversity^{S}	0.25	**0.56**	0.37
Explained variability	28%	24%	

Table S10. Varimax rotated solution of PCA: 9-hour model

Behavioural index	Component PC1	PC2	Communalities
Activity diversity^{S}	**0.88**	0.27	0.85
Passive affiliation^{P}	**-0.80**	0.11	0.66
Exploration^{F}	**0.80**	0.04	0.65
Threats(in)^{F}	**0.79**	-0.03	0.62
Grooming(in)^{F}	**0.72**	**0.45**	0.72

Terminate grooming^{F}	**0.64**	**0.54**	0.70
Invite grooming(rec)^{F}	**0.62**	0.24	0.45
Vigilance^{F}	**0.60**	**-0.42**	0.53
Object sniffing^{F}	**0.56**	-0.30	0.40
Resting^{P}	**-0.56**	**-0.42**	0.49
Grimace^{F}	**0.52**	-0.10	0.28
Self-grooming^{F}	**0.45**	-0.17	0.23
Monitoring^{P}	0.36	-0.06	0.14
Scent marking^{F}	0.34	0.05	0.12
Departures(in)^{F}	-0.27	**0.90**	0.88
Scratching^{F}	-0.16	**-0.82**	0.71
Approaches(in)^{F}	-0.18	**0.82**	0.71
Affiliation^{P}	-0.23	**0.78**	0.65
Contact aggression(in)^{F}	-0.17	**0.73**	0.57
Carrying food away(in)^{F}	-0.07	**0.62**	0.39
Grooming(rec)^{F}	0.16	**0.59**	0.37
Substrate diversity^{S}	0.17	**0.58**	0.36
Invite grooming(in)^{F}	0.16	**0.51**	0.29
Explained variability	26%	25%	

Table S11. Varimax rotated solution of PCA: 8-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Activity diversity^{S}	**0.89**	0.18	0.82
Grooming(in)^{F}	**0.82**	0.29	0.76
Threats(in)^{F}	**0.80**	-0.01	0.65
Passive affiliation^{P}	**-0.80**	0.20	0.68
Exploration^{F}	**0.76**	0.06	0.58
Terminate grooming^{F}	**0.75**	0.39	0.71
Invite grooming(rec)^{F}	**0.67**	0.28	0.53
Grimace^{F}	**0.54**	-0.08	0.30
Vigilance^{F}	**0.54**	**-0.45**	0.50
Resting^{P}	**-0.53**	-0.38	0.43
Object sniffing^{F}	**0.51**	-0.28	0.34
Self-grooming^{F}	**0.41**	-0.19	0.20
Scent marking^{F}	0.36	0.07	0.13
Monitoring^{P}	0.27	-0.09	0.08

Departures(in)[F]	-0.25	**0.90**	0.87
Scratching[F]	-0.18	**-0.83**	0.72
Approaches(in)[F]	-0.18	**0.81**	0.69
Affiliation[P]	-0.15	**0.79**	0.65
Contact aggression(in)[F]	-0.19	**0.74**	0.58
Substrate diversity[S]	0.23	**0.59**	0.40
Carrying food away(in)[F]	0.03	**0.58**	0.34
Invite grooming(in)[F]	0.14	**0.58**	0.35
Grooming(rec)[F]	0.25	**0.54**	0.35
Explained variability	27%	24%	

Table S12. Varimax rotated solution of PCA: 7-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Activity diversity[S]	**0.87**	0.22	0.80
Grooming(in)[F]	**0.87**	0.22	0.80
Passive affiliation[P]	**-0.80**	0.21	0.69
Terminate grooming[F]	**0.79**	0.33	0.73
Threats(in)[F]	**0.77**	-0.01	0.59
Exploration[F]	**0.73**	0.09	0.54
Invite grooming(rec)[F]	**0.64**	0.28	0.48
Grimace[F]	**0.61**	-0.06	0.38
Resting[P]	**-0.49**	**-0.44**	0.44
Vigilance[F]	**0.49**	**-0.42**	0.42
Object sniffing[F]	**0.48**	-0.25	0.29
Self-grooming[F]	**0.43**	-0.18	0.22
Scent marking[F]	0.36	0.12	0.14
Monitoring[P]	0.18	-0.08	0.04
Departures(in)[F]	-0.28	**0.89**	0.88
Scratching[F]	-0.20	**-0.83**	0.74
Approaches(in)[F]	-0.21	**0.81**	0.70
Contact aggression(in)[F]	-0.19	**0.79**	0.66
Affiliation[P]	-0.09	**0.78**	0.62
Substrate diversity[S]	0.24	**0.60**	0.42
Invite grooming(in)[F]	0.17	**0.58**	0.36
Carrying food away(in)[F]	0.03	**0.53**	0.29
Grooming(rec)[F]	0.33	**0.47**	0.33

Explained variability	27%	23%	

Table S13. Varimax rotated solution of PCA: 6-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Grooming(in)^{F}	**0.88**	0.01	0.78
Passive affiliation^{P}	**-0.88**	0.14	0.79
Activity diversity^{S}	**0.85**	0.19	0.76
Terminate grooming^{F}	**0.83**	0.10	0.70
Threats(in)^{F}	**0.80**	-0.02	0.64
Invite grooming(rec)^{F}	**0.68**	0.22	0.51
Exploration^{F}	**0.65**	-0.08	0.43
Grimace^{F}	**0.61**	-0.11	0.38
Grooming(rec)^{F}	**0.52**	**0.40**	0.44
Object sniffing^{F}	**0.50**	-0.33	0.36
Self-grooming^{F}	**0.49**	-0.19	0.27
Resting^{P}	**-0.48**	**-0.44**	0.42
Scent marking^{F}	0.28	0.03	0.08
Departures(in)^{F}	-0.25	**0.87**	0.82
Scratching^{F}	-0.19	**-0.83**	0.72
Affiliation^{P}	0.04	**0.80**	0.65
Approaches(in)^{F}	-0.20	**0.79**	0.67
Contact aggression(in)^{F}	-0.19	**0.78**	0.64
Substrate diversity^{S}	0.14	**0.67**	0.47
Carrying food away(in)^{F}	0.10	**0.55**	0.32
Invite grooming(in)^{F}	0.32	**0.44**	0.29
Vigilance^{F}	0.35	**-0.40**	0.29
Monitoring^{P}	0.19	-0.21	0.08
Explained variability	28%	22%	

Table S14. Varimax rotated solution of PCA: 5-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Grooming(in)^{F}	**0.87**	-0.10	0.77
Terminate grooming^{F}	**0.85**	-0.03	0.73
Passive affiliation^{P}	**-0.84**	0.26	0.77

Activity diversity^S	**0.81**	0.20	0.70
Invite grooming(rec)^F	**0.72**	0.13	0.53
Threats(in)^F	**0.67**	0.09	0.46
Grooming(rec)^F	**0.65**	0.20	0.46
Self-grooming^F	**0.55**	-0.11	0.32
Grimace^F	**0.53**	-0.06	0.28
Object sniffing^F	**0.52**	-0.38	0.42
Invite grooming(in)^F	**0.51**	0.23	0.31
Exploration^F	**0.45**	0.00	0.20
Scent marking^F	0.33	-0.01	0.11
Departures(in)^F	-0.21	**0.89**	0.84
Approaches(in)^F	-0.17	**0.84**	0.73
Scratching^F	-0.29	**-0.79**	0.71
Contact aggression(in)^F	-0.19	**0.78**	0.64
Affiliation^P	0.14	**0.72**	0.54
Substrate diversity^S	0.21	**0.67**	0.50
Carrying food away(in)^F	0.17	**0.56**	0.34
Resting^P	**-0.41**	**-0.54**	0.46
Vigilance^F	0.05	-0.35	0.13
Monitoring^P	0.10	-0.33	0.12
Explained variability	27%	21%	

Table S15. Varimax rotated solution of PCA: 4-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Grooming(in)^F	**0.87**	-0.01	0.75
Terminate grooming^F	**0.85**	0.04	0.72
Invite grooming(rec)^F	**0.81**	0.05	0.66
Passive affiliation^P	**-0.81**	0.17	0.68
Grooming(rec)^F	**0.74**	0.08	0.56
Activity diversity^S	**0.67**	0.37	0.59
Object sniffing^F	**0.64**	-0.34	0.53
Grimace^F	**0.58**	0.06	0.34
Threats(in)^F	**0.57**	0.25	0.39
Invite grooming(in)^F	**0.54**	0.05	0.30
Self-grooming^F	**0.45**	-0.09	0.21
Scent marking^F	**0.40**	0.01	0.16

Exploration[F]	0.29	0.21	0.13
Departures(in)[F]	-0.29	**0.85**	0.80
Approaches(in)[F]	-0.26	**0.82**	0.74
Scratching[F]	-0.22	**-0.80**	0.68
Contact aggression(in)[F]	-0.28	**0.79**	0.70
Substrate diversity[S]	0.10	**0.72**	0.53
Affiliation[P]	0.13	**0.63**	0.41
Resting[P]	-0.30	**-0.61**	0.47
Carrying food away(in)[F]	0.16	**0.55**	0.33
Monitoring[P]	0.10	-0.35	0.14
Vigilance[F]	-0.09	-0.26	0.08
Explained variability	26%	21%	

Table S16. Varimax rotated solution of PCA: 3-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Terminate grooming[F]	**0.89**	-0.11	0.80
Grooming(in)[F]	**0.87**	-0.15	0.79
Grooming(rec)[F]	**0.81**	-0.11	0.67
Invite grooming(rec)[F]	**0.78**	-0.08	0.61
Passive affiliation[P]	**-0.75**	0.27	0.63
Threats(in)[F]	**0.68**	0.00	0.47
Activity diversity[S]	**0.56**	0.35	0.44
Invite grooming(in)[F]	**0.55**	-0.13	0.32
Grimace[F]	**0.49**	0.22	0.29
Vigilance[F]	-0.32	-0.11	0.12
Scent marking[F]	0.19	0.03	0.04
Departures(in)[F]	-0.18	**0.87**	0.79
Approaches(in)[F]	-0.14	**0.82**	0.70
Scratching[F]	**-0.42**	**-0.78**	0.79
Contact aggression(in)[F]	-0.10	**0.72**	0.53
Substrate diversity[S]	0.08	**0.66**	0.45
Resting[P]	-0.21	**-0.60**	0.40
Carrying food away(in)[F]	0.22	**0.58**	0.39
Affiliation[P]	0.39	**0.57**	0.49
Object sniffing[F]	0.35	**-0.50**	0.37
Self-grooming[F]	0.17	-0.37	0.17

Monitoring^{P}	0.15	-0.33	0.13
Exploration^{F}	0.00	0.22	0.05
Explained variability	24%	21%	

Table S17. Varimax rotated solution of PCA: 2-hour model

	Component		
Behavioural index	PC1	PC2	Communalities
Terminate grooming^{F}	**0.88**	-0.15	0.80
Grooming(in)^{F}	**0.88**	-0.22	0.82
Invite grooming(rec)^{F}	**0.83**	0.12	0.71
Grooming(rec)^{F}	**0.80**	0.09	0.64
Passive affiliation^{P}	**-0.65**	0.39	0.57
Invite grooming(in)^{F}	**0.64**	0.08	0.41
Threats(in)^{F}	**0.63**	0.00	0.40
Activity diversity^{S}	**0.51**	0.34	0.37
Object sniffing^{F}	0.34	-0.30	0.21
Grimace^{F}	0.33	0.12	0.12
Scent marking^{F}	0.29	0.06	0.09
Self-grooming^{F}	0.22	-0.22	0.10
Departures(in)^{F}	-0.33	**0.85**	0.83
Scratching^{F}	-0.29	**-0.84**	0.80
Approaches(in)^{F}	-0.29	**0.75**	0.64
Contact aggression(in)^{F}	-0.10	**0.73**	0.54
Substrate diversity^{S}	0.15	**0.59**	0.37
Affiliation^{P}	0.35	**0.58**	0.46
Resting^{P}	-0.16	**-0.55**	0.33
Carrying food away(in)^{F}	0.18	**0.43**	0.22
Monitoring^{P}	0.26	-0.29	0.15
Vigilance^{F}	-0.21	-0.26	0.11
Exploration^{F}	-0.07	0.21	0.05
Explained variability	23%	19%	

Table S18. Varimax rotated solution of PCA: 1-hour model

	Component	
Behavioural index	PC1	Communalities
Grooming(in)^{F}	**0.77**	0.60

Terminate grooming^F	**0.73**	0.54
Departures(in)^F	**-0.72**	0.52
Scratching^F	**0.65**	0.42
Approaches(in)^F	**-0.62**	0.39
Contact aggression(in)^F	**-0.59**	0.35
Monitoring^P	**0.59**	0.35
Substrate diversity^S	**-0.58**	0.34
Object sniffing^F	**0.53**	0.29
Passive affiliation^P	**-0.51**	0.26
Resting^P	**0.51**	0.26
Exploration^F	**-0.44**	0.20
Scent marking^F	**0.42**	0.18
Grooming(rec)^F	**0.42**	0.18
Invite grooming(in)^F	0.36	0.13
Invite grooming(rec)^F	0.31	0.10
Carrying food away(in)^F	-0.28	0.08
Threats(in)^F	0.26	0.07
Affiliation^P	-0.23	0.05
Self-grooming^F	0.21	0.04
Activity diversity^S	-0.19	0.04
Vigilance^F	0.01	0.00
Grimace^F	0.00	0.00
Explained variability	23%	

Table S19. Comparison of cotton-top tamarin behaviour-based Extraversion with common marmoset questionnaire-based dimensions

Cotton-top tamarin		Common marmoset (Koski et al., 2017)		Common marmoset (Iwanicki and Lehmann, 2015)	
Index	Formula	Adjective	Definition	Adjective	Definition
Extraversion		**Inquisitiveness**		**Openness**	
(-)Resting[P]	(rest + look + watch + sit + lie) / (move + jump + cling + hang)	(-)Lazy	"Monkey has inexpressive reactions, is inactive and slow."	Active	"Spends considerable time moving around or engaging in some energetic behaviour"
Activity diversity[S]	Shannon diversity index of activity types	Active	"Monkey seeks physical activity, and is fast and agile."		
Exploration[F]	(exploration + object manipulation + search)/hour	Exploratory	"Monkey is seeking new objects in its environment and seems eager to learn about them as much as possible."	Curious	"Readily explores new situations, seeking out or investigating novel situations"
Object sniffing[F]	object sniffing/hour				
(-)Passive affiliation[P]	(contact + proximity)/[contact + proximity + social play + groom(in) + groom(rec)]	(-)Solitary	"Monkey prefers to spend considerable time alone not seeking or even directly avoiding contact with others		
Grooming(in)[F]	groom(in)/hour				
Monitoring[P]	watch/sample	Alert	"Monkey pays attention to other monkeys' behavior and its environment. Monkey does not seem to be tense; it is keeping an eye on the general situation."		
Vigilance[F]	alert/hour			Vigilant	"Attentive, watchful, notices with special attention; not oblivious to surroundings"
				Extraversion	
Threats(in)[F]	(facial threat + open mouth display + headshake + body display + tongue flick)/hour			Dominant	"Able to displace, threaten, or take food from other animals"

Note. (-) negative loading on component

Table S20. Comparison of cotton-top tamarin behaviour-based Confidence with common marmoset questionnaire-based dimensions

Cotton-top tamarin		Common marmoset (Koski et al., 2017)		Common marmoset (Iwanicki and Lehmann, 2015)	
Index	Formula	Adjective	Definition	Adjective	Definition
Confidence		**Assertiveness**		**Extraversion**	
Contact aggression(in)[F]	(general aggression + bit + beat + grab + grasp + chase + fight + face + push + displace)/hour)	Dominant	"Monkey easily gets its own way, is able to control others and decisively intervenes in social interactions."	(-)Submissive	"Gives in readily to others"
		(-)Vulnerable	"Monkey is prone to be physically or emotionally hurt as a result of aggression or assertive behavior by another individual."	Effective	"Gets own way; can control others"
		(-)Sympathetic	"Monkey seems to be considerate and kind towards others as if sharing their feelings or trying to provide reassurance."	Bold	"Daring and fearless, not restrained or tentative. Not timid, shy, or coy."
Substrate diversity[S]	Shannon diversity index of substrate types	(-)Cautious	"Monkey avoids risky behaviors and situations."	(-)Cautious	"Exhibits a careful, measured approach to investigations; avoids risky behaviors"
		(-)Timid	"Monkey lacks self-confidence, is easily alarmed and is hesitant to venture into new social or non-social situations."		
(-)Scratching[F]	scratch/hour	(-)Anxious	"Monkey often seems distressed, troubled, or in a state of uncertainty."		
Carrying food away(in)[F]	carry food away(in)/hour	Selective	"Monkey tries to select the best food or place if having chance to do so, seems picky."	Stingy	"Excessively covetous of favored resources(food, etc.); unwilling to share"
		Agreeableness			
Affiliation[P]	[contact + proximity + social play + groom(in) + groom(rec)]/hour	Sociable	"Monkey seeks, enjoys and keeps the company of other monkeys."	(-)Solitary	"Prefers to spend considerable time alone; avoids contact with other animals"
Invite grooming(in)[F]	groom invite(in)/hour	Affectionate	"Monkey has a warm attachment or closeness with others. Monkey's behavior expresses the positive relationship to others."	Confident	"Behaves in a positive, assured manner; not restrained or tentative"
Approaches(in)[F]	approach(in)/hour				

Confidence		Agreeableness		Extraversion	
Grooming(rec)^{F}	groom(rec)/hour	Popular	"Monkey is often sought out as a companion by others"	(-)Depressed	"Often appears isolated, withdrawn, has reduced activity; socially unresponsive"

Note. (-) negative loading on component